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Towards a New Dynamic Measure of Competitive Balance: A Study Applied to Australia's Two Major Professional 'Football' Leagues*

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Abstract: A new measure for competitive balance between seasons is proposed, which takes the form of a mobility gain function, based on each team's win ratios from the current and previous seasons. This 'dynamic' function measures competitive balance within a one-period change framework. While it is not suggested that this measure replace useful existing within-season measures, such as the widely used actual-to-idealised standard deviation (ASD/ISD) ratio, this measure does overcome one of the shortcomings of within-season measures – that is, the ability to pick up uncertainty of outcome from season to season, rather than merely from round-to-round. Hence, it is suggested that this measure could be used in conjunction with within-season measures in time-series analysis. An application to Australia's Australian Football League (AFL) and National Rugby League (NRL) over a century of data reveals numerous interesting comparisons.

I. INTRODUCTION

Competitive balance (CB) refers simply to the degree of evenness in sports leagues. However, the idea of measuring and quantifying CB is far from clear-cut, given the diversity of defining it precisely. Most notably, complications arise when one considers the distinction between the three often-cited dimensions of CB. Firstly, there is the notion of uncertainty of outcome of any single match/contest, to which the 'uncertainty of outcome' hypothesis referred originally. Secondly, we have the concept of parity or otherwise in terms of the distribution of wins between teams in any given season, or 'within-season' CB. Finally, the idea of an

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equal distribution of premierships (titles) over the medium-to-long run (or 'between-season' CB), is also of importance.

The former is often proxied in cross-sectional studies by the use of betting market data; see Owen and Weatherston (2004) as a recent example for data from the 'Super 14' SANZAR provincial league in rugby union. However, this study is more concerned with comparing and contrasting the experiences of 'within-season' CB and 'between-season' CB in Australia's two largest professional sports leagues. These leagues are: (i) the Australian Football League (AFL); and (ii) the National Rugby League (NRL). As will be demonstrated, the historical comparison between the AFL and NRL with respect to CB is very different depending on which mode of CB is the basis for evaluation. Subsequently, an attempt to reconcile this apparent conundrum is made via the proposal of a new CB measure, which takes the form of a gain function of each team's standing in a given season relative to the previous season, and aggregating these individual team gain functions league-wide. The gain function will take a higher value when there is greater instability and central tendency from season-to-season in the win percentages of teams in the league.[1] A thorough empirical investigation of this measure is undertaken in this paper using all available historical data in both leagues, and the results are analysed.

The motives for investigating these specific issues using the AFL and NRL specifically as case examples are strong. Both competitions have long and illustrious histories. The AFL (formed in Melbourne as the Victorian Football League in 1896) and the NRL (formed in Sydney as the New South Wales Rugby League in 1907) have a century-long tradition of league competition, uninterrupted even by World Wars I and II.[2] Further, the respective traditional heartlands of both codes of football are almost mutually exclusive geographically, with Australian Rules football the dominant winter sport in Victoria, South Australia, Western Australia, Tasmania and parts of Southern New South Wales. Meanwhile, Rugby League is most influential in most of New South Wales, the Australian Capital Territory and Queensland. Moreover, until the commencement of national expansion of both leagues in the early 1980s, there was virtually no encroachment by either competition on the other's territory, meaning that both leagues had a near-monopoly status in their respective traditional markets.[3] Even in the current day, these leagues still wield a considerable amount of monopoly power in those traditional markets. Furthermore, these leagues exhibit a number of interesting characteristics that are highly unique to Australian professional sports. However, it is worth noting that the current study could be applied to other professional sports, though in the Australian context, there is an insufficient sample length for other sports, as other 'national' leagues are a relatively new phenomenon.

Despite the geographical divide, there is still some degree of competition between the leagues (and to an extent with other, smaller leagues). While the AFL is the larger of the two leagues by any meaningful measure, the NRL is itself still significantly bigger than the next biggest of the other professional sports leagues in Australia. Nevertheless, despite the competition, each of these leagues has always kept a keen watch over developments in the other, in an attempt to

[1] In theory, this measure has other possible applications in professional sports, such as the distribution of revenues between teams, or the distribution of income between athletes in individualistic sports.

[2] In fact, the NRL suffered neither a reduction in the number of teams nor the number of rounds during either of the World Wars.

[3] This is also true when comparing these leagues to other sports, as there was no truly Australian national league in any sport until football (soccer) and basketball in 1977 and 1979, respectively.

learn from the successes and failures of its apparent rival. On this theme, one notable difference between the two leagues is that the AFL has maintained remarkable consistency with respect to the set of participating teams, with only one team discontinued, one relocated and one merged its entire history. Comparatively, the NRL has historically experienced a significant 'churn' of teams throughout its history, culminating in the rationalisation that followed the 'Super League (SL) War' with the then Australian Rugby League (ARL) of the mid-to-late-1990s.

The remainder of this study proceeds as follows: the next section outlines the nature of existing CB measures and what they have to reveal about the AFL and NRL historical data. This is followed by a short exposition on the problems associated with these measures. In section 4, a new CB metric is outlined, which provides a possible solution to the problems outlined earlier. An empirical analysis of all seasons in the history of the AFL and NRL using the new measure is then undertaken in section 5. Section 6 concludes on a very general note.

II. BACKGROUND ON CB MEASURES

2.1. The Baseline Metric

Subsequent to the discussion in the previous section on the different dimensions of CB, it is worth pointing out that within a time-series framework; often within-season measures are required so that an annual (one season per year) series can be produced for the purposes of empirical modelling. While that limitation should, in theory, simplify the analysis, there is still significant diversity of within-season CB measurement methods. In the spirit of this theme, there are several measures utilised commonly in the sports economics literature (refer to Michie and Oughton, 2004, for a comprehensive listing).

The most popular measure within this framework is the ASD/ISD ratio, which is often attributed to Noll (1988) and Scully (1989). This ratio is defined simply as the quotient of the actual standard deviation of win ratios of all teams in the competition in season t, σ_t^A, to the 'idealised' standard deviation that would be expected in a league (with r rounds) if the result of each match were purely random, σ_t^I. This measure is represented formally by the following equation

$$\left(\frac{\sigma^A}{\sigma^I}\right)_t = \frac{\sqrt{\sum_{i=1}^{N}\left[\left(\frac{w_i}{r}\right)_t - 0.5\right]^2 \Big/ N_t}}{0.5\big/\sqrt{r_t}} \tag{1}$$

where in season t, w_i denotes the number of games won by team i, r_t is the number of games played (rounds), and the number of teams in the league is denoted by N_t. The numerator $\left(\sigma_t^A\right)$ is not affected by changes in N_t over time, since it utilises the mean squared deviation of the win ratio from its mean (0.5). The denominator $\left(\sigma_t^I\right)$ is allowed to change over time in the event that r_t changes. This is not a trivial matter given the significant number of changes to both N and r over time during the respective histories of both the AFL and NRL. A full annual time-series reproduction of the evolution of the values of N and r in both competitions is provided in *Table 1*, from which an appreciation can be gleaned as to the number of these changes.

Table 1: Annual Series of *N* and *r* in Both Leagues

	AFL		NRL			AFL		NRL	
Year	Teams	Rounds	Teams	Rounds	Year	Teams	Rounds	Teams	Rounds
1897	8	14			1952	12	19	10	18
1898	8	17			1953	12	18	10	18
1899	8	17			1954	12	18	10	18
1900	8	17			1955	12	18	10	18
1901	8	17			1956	12	18	10	18
1902	8	17			1957	12	18	10	18
1903	8	17			1958	12	18	10	18
1904	8	17			1959	12	18	10	18
1905	8	17			1960	12	18	10	18
1906	8	17			1961	12	18	10	18
1907	8	17			1962	12	18	10	18
1908	10	18	9	9/8	1963	12	18	10	18
1909	10	18	8	10	1964	12	18	10	18
1910	10	18	8	14	1965	12	18	10	18
1911	10	18	8	14	1966	12	18	10	18
1912	10	18	8	14	1967	12	18	12	22
1913	10	18	8	14	1968	12	20	12	22
1914	10	18	8	14	1969	12	20	12	22
1915	9	16	8	14	1970	12	22	12	22
1916	4	12	8	14	1971	12	22	12	22
1917	6	15	8	14	1972	12	22	12	22
1918	8	14	8	14	1973	12	22	12	22
1919	9	16	8	14	1974	12	22	12	22
1920	9	16	9	14/13	1975	12	22	12	22
1921	9	16	9	8	1976	12	22	12	22
1922	9	16	9	16	1977	12	22	12	22
1923	9	16	9	16	1978	12	22	12	22
1924	9	16	9	8	1979	12	22	12	22
1925	12	17	9	12/11	1980	12	22	12	22
1926	12	18	9	16	1981	12	22	12	22
1927	12	18	9	16	1982	12	22	14	26
1928	12	18	9	13/12	1983	12	22	14	26
1929	12	18	9	16	1984	12	22	13	24
1930	12	18	8	14	1985	12	22	13	24
1931	12	18	8	14	1986	12	22	13	24
1932	12	18	8	14	1987	14	22	13	24
1933	12	18	8	14	1988	14	22	16	22
1934	12	18	8	14	1989	14	22	16	22
1935	12	18	9	16	1990	14	22	16	22
1936	12	18	9	14/13	1991	15	22	16	22
1937	12	18	9	8	1992	15	22	16	22
1938	12	18	8	14	1993	15	20	16	22
1939	12	18	8	14	1994	15	22	16	22
1940	12	18	8	14	1995	16	22	20	22
1941	12	18	8	14	1996	16	22	20	22
1942	11	15/14	8	14	1997	16	22	12/10	22/18
1943	11	15	8	14	1998	16	22	20	24
1944	12	18	8	14	1999	16	22	17	24
1945	12	20	8	14	2000	16	22	14	26
1946	12	19	8	14	2001	16	22	14	26
1947	12	19	10	18	2002	16	22	15	24
1948	12	19	10	18	2003	16	22	15	24
1949	12	19	10	18	2004	16	22	15	24
1950	12	18	10	18	2005	16	22	15	24
1951	12	18	10	18	2006	16	22	15	24

Rounds figures in 1908, 1920, 1925, 1928, 1936 and 1942 indicate uneven distribution of byes.
In the 1943 AFL season, bottom-placed St.Kilda was eliminated after 11 matches.
NRL figures for 1997 indicate ARL/SL.

2.2. A Historical Comparison

In an attempt to compare the relative histories of within-season CB using this measure, *Figure 1* plots both the original series dating back to the commencement of both competitions, as well as a HP filter (Hodrick and Prescott, 1997) for each series, merely as a way of getting an idea of the casual trend. The HP filter is obtained by finding a solution to the optimisation problem

(2)

where X_t is the actual value of the series; Z_t is the trend (or 'growth') component; and λ is the smoothing parameter, set to the standard value of 100 in line with the suggestion of Hodrick and Prescott (1997) for annual data.

Figure 1: Original (Thin Line) and HP Trend (Bold Line) Data for the ASD/ISD Ratio in Both Leagues

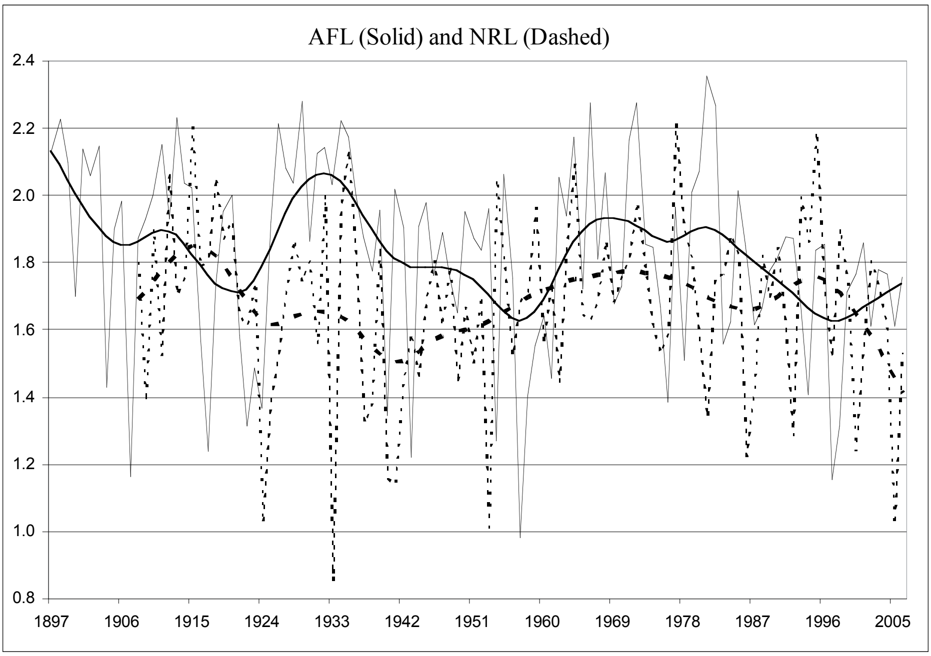


Figure 1 reveals that the ASD/ISD ratio is reasonably volatile as would be expected, since one season can be very different to the next, but that historically, using the HP trends, the NRL has historically been the more competitively balanced competition. The only three periods where this was the exception were: (i) during and immediately following World War I, a period when the then recent introduction of Melbourne metropolitan 'zoning' had succeeded initially in balancing the AFL somewhat; (ii) the late 1950s and early 1960s, a period that coincided with the domination of St. George in the NRL, which may be considered an outlier; and (iii) the mid-to-late 1990s, which may be explained by the surge of inequality in the NRL that arose from the SL War. In fact, between 1908 and 2006, the raw ASD/ISD ratio has been lower for

the AFL than the NRL in only 32 of those 99 seasons. See Booth (2004) for a more detailed analysis of the historical AFL story.

This supposition is supported by the figures in *Table 2*, which reports the summary statistics in both leagues for the ASD/ISD ratio, as well as a column for the AFL since 1908 (the year in which the NRL commenced) to equate the sample period lengths. As is shown clearly, the NRL is easily the more balanced competition historically by any criterion according to this measure. This finding is a little difficult to explain, since historically, the AFL has always used a stricter and wider range of labour market and revenue-sharing devices than the NRL, in an attempt to ensure competitive balance. Furthermore, there appears to be no obvious explanation that can be used to account for this finding.

Table 2: Summary Statistics for the ASD/ISD Ratio for Both Competitions

	AFL	AFL (1908)	NRL
Maximum	2.3549	2.3549	2.2156
Minimum	0.9813	0.9813	0.8557
Mean	1.8262	1.8172	1.6800
Median	1.8696	1.8566	1.7159
Standard Deviation	0.2877	0.2819	0.2679
<1.2	3	2	6
>2.2	9	8	2

2.3. Alternative CB Measures

In any case, other measures of CB are also popular, with a view to capturing different elements of the distribution of wins within a season. One such alternative measure is the Herfindahl Index of CB (*HICB*), based on the traditional Herfindahl Index of market concentration, expressed as

$$HICB_t = \frac{4}{N_t}\sum_{i=1}^{N}\left(\frac{w_i}{r}\right)_t^2 \tag{3}$$

Also, the Concentration Index of CB of the top x teams, $C(x)ICB_t$, specified as

$$\mathrm{C(x)ICB}_t = \frac{2}{x}\sum_{j=1}^{x}\left(\frac{w_j}{r}\right)_t \tag{4}$$

where $j = 1,2,...,x$ now refers specifically to the top x teams in rank-order. Yet another measure is the Gini Coefficient, represented as

$$\mathrm{Gini}_t = \frac{N_t^2}{4\sum_{i=1}^{N}\sum_{j=1}^{i}\left(\frac{w_j}{r}\right)_t - 2\sum_{j=1}^{N}\left(\frac{w_j}{r}\right)_t} - 1 \tag{5}$$

While not highly sensitive to changes in N_t and r_t, it could be adjusted according to the Utt and Fort (2002) methodology. Newer CB measures seem to arise on an ongoing basis, with one of the more recent contributions being the 'Index of Dissimilarity' (*ID*) as applied by Mizak, Stair and Rossi (2005), which resembles a discrete version of the Gini Coefficient

$$ID_t = \frac{\sum_{i=1}^{N} \left| \left(\frac{2w_i - r}{Nr} \right)_t \right|}{2} \tag{6}$$

Another is the 'surprise index' of Groot and Groot (2003), which is not applied in the empirical section here.

Some of these measures can also be applied to between-season CB, where the number of premierships over the period under examination is the distributed variable. However, the deficiency with this approach is that only a single observation for the entire sample period, rather than a complete time-series will result.[4] Even the ANOVA methodology used by Eckard (1998 and 2001) involves the splitting of the sample period into subsamples, each of several years length. Moreover, it is problematic to undertake such an exercise over a period where teams have entered and/or exited the league.

2.4. Comparison with Between-Season

In a casual attempt to gain an idea of historical between-season CB in the two leagues, *Tables 3* and *4* have been constructed. *Table 3* reports the frequency of successive premiership runs categorised by length for both leagues. Since a more balanced competition should have less successive premiership runs, the AFL easily stands out as the more balanced competition in this respect, according to the weighted sum (number of runs by length multiplied by their individual lengths).

Table 3: Frequency of Runs of Premierships by Length of Years for Both Competitions

Run	AFL	AFL (1908)	NRL
2	16	13	14
3	4	3	5
4	1	1	0
>4	0	0	2*
Weighted Sum	48	39	59

*Five successive premierships were won by Souths (1925-1929) and 11 by St. George (1956-1966).

An analogous way of looking at the same problem is reported in *Table 4*, which reveals the number of (non-overlapping) runs of years whereby the previous *k* premierships have all been won by different teams. Looking at the middle column, it can be seen that since 1908, there have 11 runs of four successive seasons with different premiers in the AFL, but only 5 such runs in the NRL. There has been one single run of five years with different premiers in each league. The longest runs in each competition are six years in the AFL (1963-1968) and seven in the NRL (1999-2005). Since a more balanced competition should have more of these

4 See Leeds and von Allmen (2005), appendix 5A (pp. 177-180) for a demonstration of how this eventuates.

runs, the AFL stands out again as the more balanced competition according to the weighted average.

Table 4: Non-Overlapping Runs of Years (by Length) whereby Previous *k* Premierships had been Won by *k* Different Teams for Both Competitions#

Run	AFL	AFL (1908)	NRL
4	12	11	5
5	1	1	1
>5	1	1	1
Weighted Sum	59	55	32

#In the case of overlapping runs of different lengths, preference is given naturally to the longer run.

A puzzle arises from the previous comparative analysis on CB between the AFL and NRL, which is that the evidence of CB is so significantly in favour of one league (NRL) in a within-season framework, yet so significantly in favour of the other league (AFL) in a between-season framework. While it is conceded that the two modes are obviously not equivalent, they are certainly not unrelated either – a team that is (as an extreme case) many times more powerful than any other team in a league will not only dominate over many seasons, but will also dominate within any given season as well. With this puzzle in mind, let us proceed to look at the measurement of CB in greater detail.

III. A POSSIBLE PROBLEM WITH THESE MEASURES

3.1. Effect of Outliers

The practice of using the ASD/ISD ratio as a measure of competitive balance is validated by, *inter alia*, Humphreys (2002), who describes the ASD/ISD ratio as a 'useful measure', and finds that it does a better job at explaining competitive balance than the alternative measures that he evaluates. The specification of the ASD/ISD ratio as exposed in equation (1), however, brings to light one of its possible idiosyncrasies – since it is a relative standard deviation measure, it is highly sensitive to the occasional outlier. Recent examples include the highly dominant teams (one-season basis) such as Carlton (1995) or Essendon (2000) in the AFL, as well as Parramatta (2001) or Canterbury (2002, notwithstanding the salary cap breach penalty) in the NRL. Equivalently, very poor teams such as Fitzroy in their final year of 1996 or Fremantle (2001) in the AFL, as well as Wests in their final year as an independent team of 1999 or Souths (2003) in the NRL, will also contribute heavily to the measure.

As a nice numerical illustration of the possible effect of a single outlier on the ASD/ISD ratio, if you were to take the final football (soccer) ladder (league table) from the inaugural season (2006) of the fledgling National League (A-League), by assigning a win value of 0.5 for a draw, the ASD/ISD ratio is calculated to be 1.5993. However, if the last-placed New Zealand Knights had hypothetically won one extra match at the expense of each of the other teams in the competition, the ASD/ISD ratio would have fallen to just 0.7737 – significantly more competitive than even a random distribution of wins.[5] This idiosyncrasy highlights a possible shortcoming of the ASD/ISD ratio, insofar that it could be argued that an extraordinarily good or bad team in a given season is not such a bad thing, so long as they revert towards the pack in the following season.

3.2. Short-run or Long-run Dominance

The ASD/ISD ratio is good at picking up *only* within-season effects, not mobility of teams in terms of pecking-order on the ladder. Therefore, the main disadvantage with the ASD/ISD ratio is that lack of CB, as reflected by teams occupying a similar place in the pecking order of the competition over a number of years (i.e. over time), will not be picked up very well. What may have more profound implications on CB is the scenario whereby a team finishes in the same (or at least very similar) position from year to year, without being either totally dominant or weak, like Richmond in the AFL from 1996-2006 (excluding 2001 and 2004).

As a recent AFL example of this distinction, one could take the Brisbane side that won three premierships in succession, and then lost the Grand Final in the following year (2001-2004). This was arguably detrimental to CB insofar that the competition gained a degree of predictability over that period. However, this effect will not be picked up very well by the ASD/ISD ratio measure, since they did not win the minor premiership (i.e. finished on top of the table at the conclusion of the regular or 'home-and-away' season) in any given year, thus not being the biggest outlier – hence, not contributing most heavily to the ASD. The closest equivalent (but more dated) example in the NRL would be the Parramatta side that in a six-year period (1981-1986) won four titles and one runners-up, yet achieved a win ratio of better than 0.71 only once during that period (their extremely dominant 1982 season). The measure for CB proposed here, however, will pick those effects up, as it compares the win ratios in any given season to those of the previous season, to identify if the competition has predictability via lack of variation in terms of the win ratios from season-to-season.

IV. A NEW (DYNAMIC) CB MEASURE

4.1. Basics

The (albeit limited) dynamics in this CB measure quantifies directly the gains from teams tending centrally in a given season vis-à-vis the previous season. This one-season change operator approach provides the advantage that the measure incurs a loss of only one degree of freedom, which is particularly appealing within a time-series framework. This measure has some conceptual similarities to the Markov-chain analysis approach, which can be applied in a similar way to that of Hadley, Ciecka and Krautmann (2005) for Major League Baseball data. However, the measure advocated here is more clearly defined, since there is a large number of alternative ways to define Hadley *et. al.*'s methodology of categorising teams as 'winners', 'contenders' and 'losers'. The measure also has conceptual similarities with the

[5] In line with Cain and Haddock (2006), it could be argued that the 3 points for a win and 1 for a draw system implies that a draw should be assigned a win value of only 1/3. However, if this was the case, then the previous analysis does not change much, since the implied ASD/ISD ratio changes from 1.5562 to 0.7831.

more conventional Spearman rank-order correlation matrix, but is continuous (rather than discrete) in nature, and is also asymmetric in terms of direction of movement up or down the table, thus overcoming two major problems associated with that measure.

Prior to defining the metric in question, a clarifying point needs to be made. In the construction of the proposed measure of CB, it must be remembered that CB is the objective function, and therefore, the use of the term 'gain function' henceforth refers to gains in the objective function. This point is made to clear up any possible confusion with 'gains' to individual teams, since when a dominant team comes back to the pack, the value of the gain function increases, even though that particular team is worse off.

4.2. Formal Expression

For notational purposes, let $y_{i,t}$ be known as the CB gain function for team *i* in season *t*, and c_t can be used to represent the league-aggregated CB gain function in season *t*. Using this notation, we can then formulate a couple of simplifying relations

$$W_{i,t} = \frac{w_{i,t}}{r_{i,t}} \tag{7}$$

$$\alpha = \left| W_{i,t-1} - 0.5 \right| \tag{8}$$

where $W_{i,t}$ can be thought of simply as team *i*'s win ratio in the current season, and α is simply a sensitivity parameter in the gain function that performs three functions: (i) it sets the maximum value of the gain function for each team, depending on the observed value of $W_{i,t-1}$; (ii) it ensures a monotonic transformation of $y_{i,t}$ as $W_{i,t-1}$ changes; and (iii) it ensures symmetry of gains between both dominant teams and struggling teams, if they tend centrally the following season.

We are now in a position to define the proposed competitive balance measure, the mobility gain function (*MGF*), henceforth denoted by *c*, as

$$c_t = \sum_{i=1}^{N} \frac{y_{i,t}}{N} \tag{9}$$

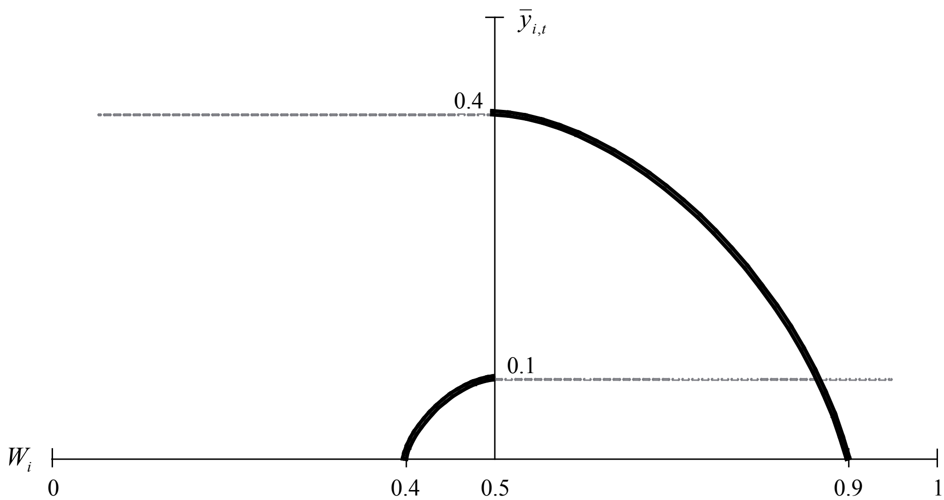
where

$$y_{i,t} \begin{cases} = 0 : \text{if either} \begin{cases} W_{i,t-1} = 0.5 \\ W_{i,t} \le W_{i,t-1} < 0.5 \\ 0.5 < W_{i,t-1} \le W_{i,t} \end{cases} \\ = -\dfrac{1}{\alpha}\left(W_{t,i} - 0.5\right)^2 + \alpha : \text{if either} \begin{cases} W_{i,t-1} < W_{i,t} < 0.5 \\ 0.5 < W_{i,t} < W_{i,t-1} \end{cases} \\ = \alpha : \text{if either} \begin{cases} W_{i,t} \le 0.5 < W_{t-1,i} \\ W_{i,t-1} < 0.5 \le W_{i,t} \end{cases} \end{cases} \tag{10}$$

where $\overline{y}_{i,t} = 0.5$ and $\underline{y}_{i,t} = 0$ (the upper and lower bounds of $y_{i,t}$, respectively). In between the two bounds, the function takes a simple quadratic form. The first case ($y_{i,t} = 0$: if $W_{i,t-1} = 0.5$) is simply a completing condition, acknowledging that if team i wins exactly half of their matches in season t, then there can be no further competitive balance gains for that team in season t+1.

Equation (10) may appear to be rather convoluted, however, $y_{i,t}$ can still be represented quite sensibly in graphical form, as in figure 2. For teams 1 and 2, imagine that $W_{1,t-1} = 0.4$ and $W_{2,t-1} = 0.9$. For team 1, which is near mid-table anyway, only low competitive balance gains are possible if they converge on 0.5. If $W_{1,t} > 0.5$, then the gains are retained at α (i.e. they cannot decline), because what we are really trying to capture here is mobility of table positions of teams from one season to the next. Therefore, even if $W_{1,t} \approx 1$, team i has still managed to work its way up to the dominant team from the bottom half of the table the year before, hence an occurrence that was highly unpredictable at t-1, which is why the maximum score is still retained. However, the gains cannot exceed α, because once the team crosses 0.5, then competitive balance is restored fully (according to the definition being applied here).

Figure 2: Illustrative Example of Gain Function for Two Teams



For team 2, however, which was the dominant team in season t-1, the potential for competitive balance gains in season t are quite significant. The reason for the quadratic specification lays in that the largest marginal increase in the gain function comes when team 2 comes back to the field slightly, increasing the uncertainty of outcome. However, the diminishing marginal gains occur because as $W_{2,t}$ declines to (say) 0.6, the outcome of games becomes highly uncertain anyway. Finally, for the sake of simplicity, it is decided that $y_{i,t} \geq 0$. This is justified on the grounds that if $W_{2,t} > 0.9$, then season t is hardly any less interesting than season t-1 anyway.

A further justification for the quadratic nature of $y_{i,t}$ in the region $\begin{cases} W_{i,t-1} < W_{i,t} < 0.5 \\ 0.5 < W_{i,t} < W_{i,t-1} \end{cases}$ lies in the evidence presented in *Table 5* for AFL historical data. If we initially impose a definition of what constitutes a 'dominant' team as one that wins at least 90 per cent of its matches in the home-and-away season, it can be seen that not one has ever failed to win the premiership in that season, though admittedly the sample is quite small.[6] Then, if the definition is eased such that any team that wins at least 85 per cent of its matches is deemed to be dominant, then it is seen that home-and-away season dominance is no longer necessarily even a near-guarantee of premiership success. In fact, the probability of winning the premiership falls to just over two-thirds, although in one case (1920), two teams were dominant, and thus it was impossible for both of these teams to win the premiership. Additionally, if the definition of dominance is weakened even further to a minimum 80 per cent winning record, then the probability of premiership success declines even further to just over one-half, although the frequency of multiple dominant teams in the same season increases markedly. Finally, for teams winning at least 60 per cent of their home-and-away matches, but less than 80 per cent (for which the term 'contender' may be preferred to 'dominant'), the probability of winning the premiership predictably plummets, to less than one-sixth.

Table 5: Frequency Distribution of Dominant Teams in the AFL and
Likelihood of Premiership Success

Criteria	Total Frequency	Premiers	%	Frequency ($i > 1$)
$W_{i,t} \geq 0.90$	6	6	100.0	0
$W_{i,t} \geq 0.85$	29	20	69.0	1
$W_{i,t} \geq 0.80$	80	43	53.8	17*
$0.60 \leq W_{i,t} < 0.80$	390	62	15.9	N/A

* However, this has occurred only twice since 1939, and not at all since 1972. On one of these occasions (1935), three teams were dominant at $W_{i,t} \geq 0.80$.

Analogously, it becomes extremely rare for a team to win a premiership as $W_{i,t} \rightarrow 0.5$ (from above). An interesting case study to demonstrate this point is the 1997 season, when Adelaide won the premiership, despite winning only 13 out of 22 home-and-away games (59.1 per cent). For good measure, they went back-to-back in 1998 with an identical home-and-away record. The former instance represented the first occasion whereby the eventual premier had won less than 60 per cent of their home-and-away matches since the infamous war-affected 1916 season in which only four teams participated and Fitzroy amazingly won the wooden spoon and premiership in the same season! Incidentally, it had been achieved once before – by Melbourne in 1900, but with the aid of an extremely idiosyncratic finals system. This historical evidence demonstrates both the high desired returns to central tendency (i.e. forcing $W_{i,t}$ towards 0.5) in season t when $W_{i,t-1} \backsimeq 1$ and the diminishing marginal returns to

[6] This kind of exercise is particularly fascinating in the context of tournament design of Australian professional sports leagues, because unlike the traditional European 'first past the post' system, leagues in most Australian sports have a finals (playoff) series. Furthermore, unlike most North-American sports, the finals series is not purely knockout-style, rather the finals series is constructed specifically to give the teams that finished higher on the ladder at the end of the home-and-away season an easier path through to the (Grand) Final, and thus an inherent advantage in the finals series. This characteristic makes the AFL and NRL somewhat unique in professional sports in this respect.

central tendency as $W_{i,t} \to 0.5$. Furthermore, it could be argued that there is no reason for the gain function to be asymmetric when $W_{i,t-1} \approx 0$ and $W_{i,t} \to 0.5$ (from below).

As an alternative form, equation (10) could also be re-written to specify a linear (rather than quadratic) gain function, $y_{i,t}^{L}$, should it be the case that simplicity were a huge issue, although in the spirit in which this gain function was constructed (and the justification provided previously), it would be less preferable to do so. Nevertheless, in proceeding to do so, one would use the following derived function in place of equations (9) and (10), in order to calculate the linearised mobility gain function, henceforth referred to as *MGFL* and denoted as c^{L}

$$c_t^L = \sum_{i=1}^{N} \frac{y_{i,t}^L}{N} \tag{11}$$

where

$$y_{i,t}^L \begin{cases} = 0 : \text{if either} \begin{cases} W_{i,t-1} = 0.5 \\ W_{i,t} \le W_{i,t-1} < 0.5 \\ 0.5 < W_{i,t-1} \le W_{i,t} \end{cases} \\ = W_{i,t} - W_{i,t-1} : \text{if } \{W_{i,t-1} < W_{i,t} < 0.5 \\ = W_{i,t-1} - W_{i,t} : \text{if } \{0.5 < W_{i,t} < W_{i,t-1} \\ = \alpha : \text{if either} \begin{cases} W_{i,t} \le 0.5 < W_{i,t-1} \\ W_{i,t-1} < 0.5 \le W_{i,t} \end{cases} \end{cases} \tag{12}$$

A quick inspection of *Table 6*, which outlines the same dominant teams analysis for the NRL as that in *Table 5*, may provide some justification for such a linear representation of the gain function. *Table 6* reveals that with dominant teams being classified at $W_{i,t} \ge 0.90$, the likelihood of winning a premiership is approximately two-thirds, although two teams were dominant on two separate occasions (1928 and 1995). While this probability may be substantially lower than the corresponding figure for the AFL, at $W_{i,t} \ge 0.85$ however, the probability of success hardly declines any further. Nor does the likelihood of premiership success decline further still at $W_{i,t} \ge 0.80$, remaining above 60 per cent and by then higher than the corresponding AFL figure. Collectively, these figures throw some caution on the assertion that high initial (but diminishing) marginal returns to central tendency are desired.

Table 6: Frequency Distribution of Dominant Teams in the NRL and Likelihood of Premiership Success¶

Criteria	Total Frequency	Premiers	%	Frequency ($i > 1$)
$W_{i,t} \ge 0.90$	16	11	68.8	2
$W_{i,t} \ge 0.85$	38	25	65.8	5
$W_{i,t} \ge 0.80$	67	41	61.2	10*
$0.60 \le W_{i,t} < 0.80$	309	56	18.1	N/A

Counting both seasons and titles won by Brisbane and Newcastle in the Super League season (1997).
*However, this has occurred only three times since 1934 and only once since 1961.

Analogously, the premiership likelihood for contenders ($0.60 \leq W_{i,t} < 0.80$) as displayed in *Table 6* is higher (18.1 per cent) than the equivalent AFL figure. Incredibly, Wests Tigers became the first NRL team to win a premiership with less than a 60 per cent home-and-away record in the extraordinarily competitive 2005 season, a feat that was astoundingly repeated by Brisbane the following year.[7] Given the mixed evidence from *Tables 5* and *6*, both the *MGF* and *MGFL* series are calculated for both leagues in the next section. In any case, having defined the CB mobility metrics, let us advance now to some empirical evidence from historical AFL and NRL data.

V. AN EMPIRICAL INVESTIGATION OF THE HISTORICAL DATA

5.1. A Simulation

Initially, as a way of demonstrating the uniqueness of these measures, take the (alternative) hypothetical two-league example of Humphreys (2002). Here, these hypothetical leagues, both involving 5 teams and 4 rounds over 5 seasons, are perfectly unbalanced by any within-season measure in each of those five seasons (see *Table 1*, p. 135). The primary difference is that in league 2, each team experiences a full rotation of ladder positions over the 5-season period, whereas in league 1, the rank order of the teams is identical in each season. Within this example, it can be shown easily that for league 1

$$c_t = c_t^L = 0 \qquad (\forall_t = 2,3,4,5)$$

whereas for league 2

$$c_t = 0.225, c_t^L = 0.2 \qquad (\forall_t = 2,3,4,5)$$

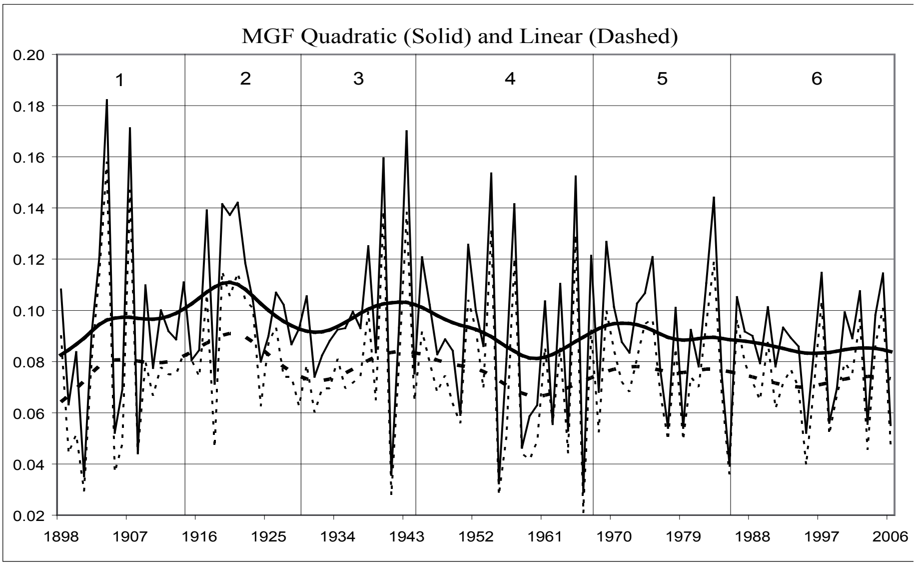
This example clearly demonstrates the ability of these measures to pick up between-season effects in CB in cases where within-season effects are identical between the two leagues.

5.2. Mobility Gain Function Results over Time

A time-series representation of both the *MGF* and the *MGFL* is provided in *Figure 3*, with the former depicted by a solid line, the latter with a dashed line. *Figure 3* is decomposed into six labelled sub-samples. These sub-samples correspond to Booth's (2004) six-period historical analysis of the various combinations of labour market and revenue-sharing devices used by the AFL. These results are supplemented by *Table 7*, which splits the sample into these six aforementioned periods. *Table 7* includes the means and standard errors (for both *MGF* and *MGFL*) for each period, as well as the difference between the two means in each period. Among Booth's most substantial findings was that (utilising the ASD/ISD ratio) CB

[7] It should be noted, however, that in the formative years of both competitions, it was much harder for NRL teams to win the premiership with a moderate home-and-away record because of differences in the respective finals systems. In comparison to the AFL (where the finals series never really consisted of less than the top four teams), the NRL seasons of 1912-1915, 1917-1921, 1925 and 1937 did not have a finals series at all (i.e. a first-past-the-post system), while in seasons 1910, 1916 and 1921-1923, only a Grand Final was played (i.e. top-two system).

Figure 3: Original (Thin Line) and HP Trend (Bold Line) AFL Data for both MGF Measures



deteriorated towards the end of (almost) each period, as clubs figured out ways to 'get around the system', at which time the AFL decided that it had to change its CB policy mix.

First of all, it can be clearly observed (concentrating primarily on the *MGF*) that there is a considerable amount of volatility in the series over time. The same is also true of the *MGFL*. This type of behaviour implies that one particular season can be substantially less or more interesting than the immediately preceding one, which is certainly plausible. Because of this volatility, a HP filter is again applied (for both the *MGF* and *MGFL*) in order to gain some insight into the underlying trends over time. Recalling at this point that, unlike the other CB measures discussed in section 2, an increase in *MGF* indicates improved CB; *Figure 3* reveals an interesting story. Specifically, the results do not conform to Booth (2004) findings. Period 2 (1914-1929, whereby in addition to free agency, Melbourne metropolitan 'zoning' was used as a talent distribution device) is the only obvious period in which the *MGF* appears to be declining structurally towards the latter stages of the sub-sample (a time at which Collingwood won their record four successive premierships), as would be expected.

Furthermore, period 6 (1985-present, the era of the national player draft, salary cap and league-revenue sharing), in stark contrast to the ASD/ISD ratio, appears to be the period with the most diminished level of CB (according to the mean), although the volatility of the series also appears to be at its lowest during this period – a finding reinforced by *Table 7*. This may indicate that a certain level of mobility has become more predictable in period 6, most likely due to the equalising effects of the (reverse-order) draft, not employed previously.[8] In other

[8] As measures of the mean, the decline in the standard deviation of both *MGF* and *MGFL* may also simply be reflective of the larger number of teams in the competition in period 6. If this were to be the primary reason for this, then it would be interesting to produce the corresponding series for the four big North-American professional leagues, in which *N* is substantially higher still.

words, the reverse-order nature of the draft has increased the propensity of struggling clubs to acquire the most talented youths, build a side over the following seasons and become strong. Then, after a few seasons of high finishes, they cease having access to the most highly talented young players coming into the league and go into decline again. Under previous regimes, this regularity caused by the draft was not present.

Table 7: Relevant *MGF* and *MGFL* Statistics within the AFL Historical Six-Period Framework

Period	$\overline{TGF_t}$ (σ_{TGF})	$\overline{TGFL_t}$ (σ_{TGFL})	$\overline{TGF_t} - \overline{TGFL_t}$
1	0.0941 (0.0394)	0.0766 (0.0360)	0.0175
2	0.1038 (0.0277)	0.0854 (0.0247)	0.0184
3	0.0980 (0.0331)	0.0791 (0.0284)	0.0189
4	0.0892 (0.0363)	0.0730 (0.0306)	0.0162
5	0.0932 (0.0248)	0.0781 (0.0192)	0.0151
6	0.0855 (0.0207)	0.0718 (0.0195)	0.0137

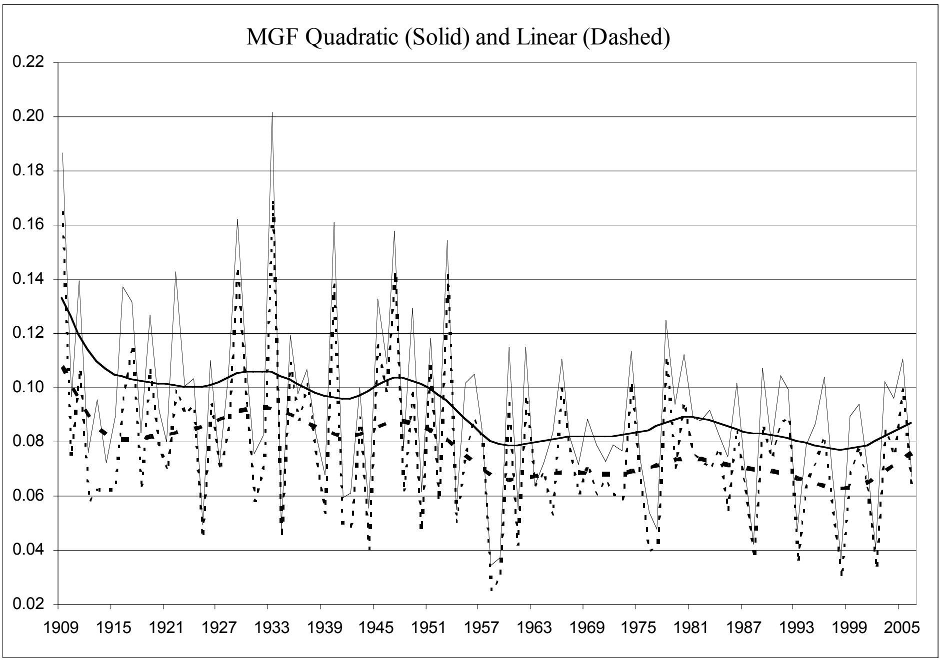
The contrast between the ASD/ISD ratio results and those obtained here illustrate the sparseness between the conceptual bases of the common within-season measures and the *MGF*. It also illustrates that, taking Booth's (2004) results, in assessing CB the AFL is more likely to react to a deterioration in CB when it becomes obvious through a lopsided ladder in a given season, as opposed to when it occurs through the same teams finishing in their customary rankings from season-to-season. In recent years, with non-Victorian teams systematically outperforming their Victorian counterparts, the latter may require attention.

Also from *Figure 3*, as would be predicted, *MGFL* is extremely strongly positively correlated with *MGF*, as can be seen clearly from both the original series and the HP trend series. However, the gap between the two HP trend series appears to narrow slightly in the latter part of the sample. This is indicative of there being more teams in recent times contributing either 0 or α to *MGF* in any given year (the only two cases where $y_{i,t} = y^L_{i,t}$), rather than $0 < y_{i,t} < \alpha$, however, the exact reasons for this are not immediately clear.

The *MGF* and *MGFL* series for the full NRL sample period are displayed in *Figure 4*, which is constructed equivalently to *Figure 3*. Here, one thing is immediately noticeable – the HP trend for both series hovers around the same level from the commencement of the league until the 1950s, then there is a significant structural decade-long decline, with stagnation once more around the same (lower) level since around 1960. This finding is consistent with the increasing HP trend of the ASD/ISD ratio from *Figure 1* during that period.

While it is difficult to find information regarding labour market and revenue-sharing devices used in the NRL prior to World War II, in the years leading up to 1960, an anecdotally ineffective series of residential zoning rules was used as the primary talent-allocating device

Figure 4: Original (Thin Line) and HP Trend (Bold Linr) NRL Data for both MGF Measures



(Dabscheck, 1993). This is consistent with the observation that declining CB forces the league to act and to make changes. While the NRL has since used several labour market devices (see Daly and Kawaguchi, 2004, p. 25) for a full list), CB has not appeared to change much in that time according to the HP trends of these measures.[9]

To further substantiate the stark contrast between the two halves of the historical NRL sample, refer to the last two columns of *Table 8*, which provide the summary statistics of the *TFG* and *TFGL* for both leagues. In these last two columns, the NRL sample is split into two equally-sized sub-samples, 1909-1957 and 1958-2006. There is strong evidence from this comparison that CB has declined markedly in the last half a century in the NRL across the board of summary statistics, irrespective of whether *MGF* or *MGFL* is the focus of attention.

5.3. Inter-League Comparison

More generally, however, we are ultimately interested in the comparison between the AFL and NRL since 1909, to see how the two leagues compare overall. This can be achieved be looking at the second and third columns of *Table 8*. Concentrating initially on the *MGF* statistics, it is seen that the mean is slightly higher for the AFL than the NRL, though the difference is quantitatively negligible. The median for the AFL is again higher than for the NRL, though the gap is still small, despite being wider than for the mean. For the *MGFL*, however, the mean is slightly higher for the NRL than for the AFL, whereas the median is actually higher for the AFL, although the quantitative difference in both cases is again negligible. Though

[9] Most of the changes since 1960 appear to have had little to do with CB-related motives.

revealing, these results unfortunately fail to shed much light on resolving the puzzle mentioned in section II.4 regarding the conflicting evidence on CB between the two leagues. While the *MGF* and *MGFL* measures capture elements of both within-season CB (favouring the NRL) and between-season CB (favouring the AFL), there appears to be little evidence to favour either league according to these measures. In other words, this 'contest' adds a draw to the one previous victory to each league.

Table 8: Summary Statistics for *MGF* and *MGFL* for Both Competitions

			MGF		
	AFL (1898)	AFL (1909)	NRL (1909)	1909-1957	1958-2006
Maximum	0.1822	0.1700	0.2018	0.2018	0.1248
Minimum	0.0289	0.0289	0.0343	0.0476	0.0343
Mean	0.0928	0.0928	0.0919	0.1027	0.0811
Median	0.0912	0.0918	0.0887	0.0998	0.0820
Standard Deviation	0.0310	0.0286	0.0319	0.0358	0.0233
			MGFL		
	AFL (1898)	AFL (1909)	NRL (1909)	1909-1957	1958-2006
Maximum	0.1581	0.1389	0.1696	0.1696	0.1117
Minimum	0.0208	0.0208	0.0250	0.0402	0.0250
Mean	0.0766	0.0766	0.0774	0.0867	0.0681
Median	0.0741	0.0743	0.0733	0.0859	0.0694
Standard Deviation	0.0267	0.0242	0.0285	0.0320	0.0208

5.4. Comparison to Other CB Measures

One final exercise that may be considered useful is to construct a correlation coefficient matrix of the various CB measures discussed thus far. To this end, *Tables 9* (AFL) and *10* (NRL) show the full-sample correlations for the following CB measures: the ASD/ISD ratio; two concentration indexes of CB, the *C3ICB* and *C5ICB*; *ID*; *HICB*; Gini; as well as the 'Range' between the win ratios of the top and bottom teams, expressed formally as[10]

$$\text{Range}_t = W_{1,t} - W_{N,t} \tag{15}$$

The various correlations of these within-season CB measures are exhibited in the first seven rows and columns of *Tables 9* and *10*. Looking at *Table 9* initially, all of these correlations are positive in sign (as would be expected) and quite strong. In fact, out of the 21 bilateral correlations between these seven measures, three have a magnitude of greater than 0.95, and all but one have a magnitude greater than 0.6. The corresponding analysis for the NRL is also compelling, but not quite as definitive – two of the pairings have a magnitude of correlation greater than 0.95, and all but four have a magnitude greater than 0.6 (all of these involving *C5ICB*).

10 There is no *C5ICB* observation for the AFL in 1916, since N=4.

Table 9: Correlation Matrix of Common Alternative Measures of Competitive Balance over the Full AFL Sample

	ASD/ISD	*C3ICB*	*C5ICB*	*ID*	*HICB*	Gini	Range	*MGF*	*MGFL*
ASD/ISD	1.0000	0.7934	0.7483	0.8899	0.9173	0.9208	0.8110	**-0.4073**	**-0.4306**
C3ICB		1.0000	0.8445	0.6919	0.6891	0.7325	0.6932	**-0.3840**	**-0.3956**
C5ICB			1.0000	0.6734	0.6159	0.6630	0.5406	**-0.3986**	**-0.4029**
ID				1.0000	0.9596	0.9728	0.6773	**-0.3002**	**-0.3424**
HICB					1.0000	0.9865	0.7974	**-0.3312**	**-0.3634**
Gini						1.0000	0.7855	**-0.3222**	**-0.3580**
Range							1.0000	**-0.3647**	**-0.3928**
MGF								1.0000	0.9700
MGFL									1.0000

Table 10: Correlation Matrix of Common Alternative Measures of Competitive Balance over the Full NRL Sample

	ASD/ISD	*C3ICB*	*C5ICB*	*ID*	*HICB*	Gini	Range	*MGF*	*MGFL*
ASD/ ISD	1.0000	0.7370	0.7177	0.6977	0.6982	0.7228	0.7242	**-0.3872**	**-0.4051**
C3ICB		1.0000	0.7583	0.7266	0.7242	0.7795	0.6435	**-0.3452**	**-0.3737**
C5ICB			1.0000	0.4424	0.3860	0.4461	0.4108	**-0.4334**	**-0.4536**
ID				1.0000	0.9406	0.9619	0.6576	**-0.1461**	**-0.1977**
HICB					1.0000	0.9891	0.8143	**-0.1230**	**-0.1344**
Gini						1.0000	0.7879	**-0.1641**	**-0.1867**
Range							1.0000	**-0.2189**	**-0.1919**
MGF								1.0000	0.9715
MGFL									1.0000

Two similarities emerge between *Tables 9* and *10*. Firstly, the strongest correlations in both leagues appear to be between the triumvirate of *ID*, *HICB* and Gini. The reason for this may not be immediately obvious, especially given that equations (3), (5) and (6) do not appear to be strikingly similar. However, this finding is not so surprising, when the conceptual similarities between these measures are considered. Secondly, the ASD/ISD ratio is the best ‘all purpose’ measure, with the weakest correlation with any other measure in either league still almost 0.7.

Finally, the correlations between these seven measures on one hand and both *MGF* and *MGFL* on the other hand, are shown in bold in the final two columns of *Tables 9* and *10*. Immediately obvious is that the sign of these correlations is negative in all cases, which is expected due to the specification of both measures and how they relate to the other measures inversely. With respect to *Table 9* initially, what is more interesting is the relatively narrow range of magnitudes of the correlations for the AFL data, all falling between 0.3 and 0.45. These magnitudes demonstrate that that *MGF* measures are picking up a very different set of CB effects compared with all of the other measures, yet they still contain some common elements to those measures – a desirable attribute. The evidence from the NRL sample is similar, but not quite as conclusive, as the range of correlation magnitudes is wider, varying between 0.1 and 0.45. The similarities between the two sets of *MGF* and *MGFL* correlations (with the other measures) in both tables are not surprising, since the correlation coefficient between *MGF* and *MGFL* is 0.97 in both leagues, demonstrating the obvious similarities between the two measures.

A comparison of the HP trends (reducing noise) of the ASD/ISD ratio from *Figure 1* for both leagues and the respective HP trends of the *MGF* from *Figures 3* (AFL) and 4 (NRL), also tells an interesting story. In the early part of the sample, the HP filters of the ASD/ISD ratio and *MGF* for the AFL data are extremely highly negatively correlated, indicating that the two measures are picking up very similar effects. However, they are highly positively correlated in the latter part of the sample, which suggests that the measures are picking up an entirely different set of effects. By contrast, for the NRL data, the HP filters of the two measures are very highly positively correlated in the formative part of the sample, and quite highly negatively correlated in the latter part.[11]

An implication of this finding is that for the periods of high positive correlation (modern AFL history, earlier NRL history), in situations when the ASD/ISD ratio fails to offer an adequate explanation of the entire underlying story, the *MGF* (and by implication *MGFL*) may offer a better alternative for the purposes of analysis. An example of this assertion is evident for the period from 1963-1968 in the AFL whereby six different teams won the premiership in successive years, indicating improved competitive balance. Concurrently, the HP trend of the *MGF* is rising, which is consistent with this, whereas the HP trend for the ASD/ISD ratio is also increasing during this period, which is an inconsistency.

VI. CONCLUSION

An exhaustive comparison of competitive balance in Australia's two biggest professional 'football' leagues, the AFL and the NRL, has exposed a most fascinating case study. A historical comparison of the ASD/ISD ratio for both leagues reveals the NRL to be the more competitive league in a within-season framework; however, a casual analysis of runs with respect to the distribution of premierships shows the AFL to be the more competitive league in a between-season framework. However, there are some obvious problems with looking only at within-season CB, and measurement issues are obviously problematic when between-season analysis is chosen for investigation. Some of these problems were discussed at length.

With this in mind, a new measure of competitive balance was proposed, utilising the win ratios of all teams in the league in successive seasons, producing a quadratic one-period change metric that takes the form of a mobility gain function. This dynamic specification picks up movements of teams up and down the ladder over time, and while it does not solve the problems associated with measuring competitive balance discussed previously, it does offer a useful bridge linking the within- and between-season analyses. Further, some of the specifics of the measure were discussed, and a linearised variant of the metric was also offered.

Using these derived measures (which are highly positively correlated with each other), the historical evidence is inconsistent to some degree with that from utilising the ASD/ISD

[11] Actual figures for these correlation coefficients are as follows: AFL: -0.9137 (1898-1945); 0.6121 (1946-2006); NRL: 0.6604 (1911-1944); -0.5147 (1945-2006).

ratio, as posited by Booth (2004). It is found according to these measures that while there appears to have been no large structural change in competitive balance in the AFL over the sample (though the standard deviation has declined), there was a decade-long structural decline in competitive balance that occurred in the NRL during the 1950s. Ultimately, by comparing the two leagues in terms of the level of competitive balance over their respective histories, it is very difficult to separate the two via the means and medians of these measures. Unfortunately, this result does not help to reconcile the apparent superiority of the NRL competitive balance over the AFL in terms of within-season, and the contrary result in terms of between-season.

Finally, a correlation matrix analysis involving several common within-season measures confirms that they are all picking up similar effects, whereas these two new measures are picking up a substantially different set of factors. Therefore, while it is not being suggested that these new measures take the place of the existing within-season measures, they do help overcome some of the problems of the within-season measures, and hence could be considered to be useful complements in any time-series historical or empirical study involving professional sports leagues.

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